

TREATING INTACT CERVICAL CANCER WITH INTENSITY-MODULATED RADIOTHERAPY: MAXIMIZED BLADDER-FILLING CHANGE AND TUMOR EXTENT ARE ASSOCIATED WITH ORGAN MOTION

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Introduction : The aim of the present study is to evaluate the impact of bladder filling on uterus-cervix mobility in patients with cervical cancer and an intact uterus treated by intensity-modulated radiotherapy (IMRT).

Methods and Materials : Twenty-two consecutive women with cervical cancer (FIGO stage IB-IVB) receiving pelvic IMRT were selected for analysis. Two series of treatment planning CT scans, one with a full bladder and the other with an empty bladder, were acquired. The target volumes and normal tissues were contoured on each CT scan according to the updated guidelines and staging MRI. We determined the centroid positions of the cervical tumor and uterus, then correlated the centroid displacement to the delta volume of the bladder (DVB; defined as the volume difference between full and empty urinary bladders; the maximized bladder filling change).

Results : A significant mobility of the uterus-cervix according to bladder filling was observed on the superior-inferior axis only. For all patients, displacement of the uterus-cervix on the superior-inferior axis was significantly correlated with the DVB (adjusted $R^2= 0.49$, $p= 0.0005$). Among 8 patients with cervical tumor invading less than one-half of the uterus, the target displacement affected by DVB was well-described by linear regression (adjusted $R^2= 0.61$, $p= 0.0008$). For those with bulky tumor extent, the correlation between target displacement and DVB was much less apparent. For patients have anteverted uterus ($n= 11$), the DVB was associated with cervix-uterus motion on superior-inferior axis (adjusted $R^2 =0.40$, $p= 0.022$), while for those with retroverted or tip-up uterus, there was no significant correlation. After a multivariate linear regression analysis, DVB and tumor extent were significantly correlated with uterus-cervix motion.

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Conclusion : The maximized bladder filling change (DVB), and tumor extent, were significantly correlated with uterus-cervix centroid displacement on the superior-inferior axis of cervical cancer patients.

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Key words: Cervical cancer, Delta volume of bladder, IMRT, Organ motion

INTRODUCTION

Cervical cancer is the third most common cancer in women worldwide [16] and radiotherapy has played an important role in the treatment of advanced cervical cancer [17]. Conventional whole pelvic radiotherapy, using the four-field “box” technique, provides a homogenous dose distribution covering the primary tumor and regional lymph nodes. Not surprisingly, a large volume of normal tissue, such as bowel, rectum, and urinary bladder, are encompassed in the prescribed-high dose target. Therefore, acute and late toxicities are not uncommon among patients treated with conventional non-conformal whole-pelvis radiotherapy [13].

Over the past decade, intensity-modulated-radiotherapy (IMRT) has been increasingly adopted in treating patients with cervical cancer [21]. Several studies have demonstrated that IMRT provides a highly-conformal dose distribution, reducing the volume of normal tissues irradiated [7, 13, 22, 23], while achieving excellent coverage of the clinical target volume (CTV). Moreover, preliminary studies have indicated that the physical superiority of IMRT can be translated to lower clinical toxicities and favorable disease control [6, 12].

However, the uncertainty of organ motion and target dynamics has hindered the adoption of IMRT on cervical cancer with an intact uterus [15]. Several studies have demonstrated that the cervix and uterus move considerably

according to bladder and rectal filling variations [4, 5, 9, 14, 26, 27]. Among those factors affecting CTV positions, the variations in urinary bladder volume potentiates the largest impact [1, 4, 5, 26]. To ensure adequate target coverage, the most common approach is a “population-based” margin, which applies substantial margins derived from a standardized population to construct a planning target volume (PTV). Notably, there were significant inter-patient variations of CTV motions among those studies [3, 8, 18, 28]. A uniform margin would ostensibly irradiate excess normal tissue in patients with a relatively immobile uterus, or miss the target in patients with substantial organ motion. In the RTOG 0418 trial, a phase II study evaluating IMRT as post-operative adjuvant therapy for patients with gynecologic cancers, the internal target volume (ITV) accounting for individualized organ motion affected by bladder volume was first introduced [15]. The adequate margin of an intact uterus is still evolving as ongoing research findings accumulate.

The aim of this analysis was to evaluate the impact of bladder filling status on cervix-uterus mobility in patients with cervical cancer and an intact uterus treated by IMRT.

MATERIAL AND METHODS

Patient data

Between March 2011 and February 2012, 22 consecutive women diagnosed with advanced cervical carcinoma were selected